Introduction to Energy Transmission and Distribution

IT8411 36 weeks

Table of Contents

Acknowledgments

The components of this instructional framework were developed by the following curriculum development panelists:

Charlie Barksdale, Utilities and Performance Contracting Manager, Virginia Department of Mines, Minerals, and Energy, Richmond
James Egenrieder, Engineering Education Research Faculty and Director, Virginia Tech National Capital Region, Blacksburg
Sasha Furdak-Roy, Operations Center Manager, Columbia Gas of Virginia, Inc., Petersburg
Jason Gambill, Manager, Electric Safety and Training, Dominion Energy, Richmond

Matt Kellam, Military and Recruitment Program Coordinator, Dominion Energy, Richmond
David Kenealy, Special Assistant to the Executive Director, Southern Virginia Higher Education Center, South Boston
Beth Murtha, Project Manager, Framatome Inc., Lynchburg
Remy Pangle, Director and Education Manager, Center for the Advancement of Sustainable Energy, James Madison University, Harrisonburg
Jeremy Phelps, Supervisor, Power Delivery Safety and Training, Dominion Energy, Richmond
Cathy Woody, Workforce Development Manager, Framatome Inc., Lynchburg

Correlations to the Virginia Standards of Learning were reviewed and updated by:

Leslie R. Bowers, English Teacher (ret.), Newport News Public Schools
Vickie L. Inge, Mathematics Committee Member, Virginia Mathematics and Science Coalition
Anne F. Markwith, New Teacher Mentor (Science), Gloucester County Public Schools
Michael Nagy, Social Studies Department Chair, Rustburg High School, Campbell County Public Schools

The framework was edited and produced by the CTE Resource Center:

Averill P. Byrd, Writer/Editor
Kevin P. Reilly, Administrative Coordinator

Virginia Department of Education Staff

Dr. Lynn Basham, Specialist, Technology Education and Related Clusters
J. Anthony Williams, Curriculum and Instruction Coordinator
Dr. David S. Eshelman, Director, Workforce Development and Initiatives
George R. Willcox, Director, Operations and Accountability

Office of Career, Technical, and Adult Education
Virginia Department of Education

Course Description

Suggested Grade Level: 9 or 10

This course provides students with a foundation in electricity and gas transmission, distribution, and storage, including smart grids and distributed energy. Students participate in hands-on activities such as designing and building models of grids and gas systems. Students explore policies, trends, and careers in energy.

Task Essentials Table

- Tasks/competencies designated by plus icons (⊕) in the left-hand column(s) are essential
- Tasks/competencies designated by empty-circle icons (○) are optional
- Tasks/competencies designated by minus icons (⊖) are omitted
- Tasks marked with an asterisk (*) are sensitive.

Task Number	IT8411	Tasks/Competencies	
Understanding Basic Energy Concepts			
39	⊕	Define *energy*.	
40	⊕	Identify units of measurement related to power.	
41	⊕	Describe the primary forms of energy and their uses.	
42	⊕	Describe how renewable and non-renewable sources of energy are used.	
43	⊕	Demonstrate energy transformation.	
44	⊕	Define electrical energy.	
Exploring Electricity and Gas Fundamentals			
45	⊕	Follow safety guidelines.	
46	⊕	Demonstrate the use of tools and applications in electricity and gas.	
47	⊕	Demonstrate the use of instruments to measure units.	
48	⊕	Convert units of measure.	
49	⊕	Describe characteristics of series, parallel, and combination circuits.	
Understanding the Electrical Grid			
50	⊕	Define the grid.	

51	⊕	Explain the history of the grid.	
52	⊕	Illustrate the grid.	
53	⊕	Research career opportunities in electric transmission and distribution.	
Understanding Gas Systems			
54	⊕	Define a natural gas system.	
55	⊕	Identify uses of natural gas.	
56	⊕	Explain key developments in gas systems.	
57	⊕	Illustrate a gas system.	
58	⊕	Research career opportunities in gas transmission and distribution.	
Investigating Regulatory Policies in Energy			
59	⊕	Describe how federal and state agencies regulate the energy business.	
60	⊕	Identify other agencies involved in the permitting and oversight of energy businesses.	
61	⊕	Describe the role of independent regional transmission organizations (RTOs).	
62	⊕	Research regulations that ensure public safety.	
Exploring Technology Trends in Energy			
63	⊕	Define distributed energy.	
64	⊕	Describe microgrids.	
65	⊕	Design a microgrid.	
66	⊕	Compare a smart grid to a traditional distribution grid.	
67	⊕	Research trends in energy storage.	
68	⊕	Investigate research and development (R&D) that address future challenges in energy.	

Legend: ⊕Essential ○Non-essential ⊖Omitted

Curriculum Framework

Understanding Basic Energy Concepts

Task Number 39

Define *energy*.

Definition

Definition should include

- energy as the ability to produce change or do work
- the difference between kinetic and potential energy
- the difference between energy and power
    - energy – the capacity to do work
    - power – the rate at which work is done
- energy derived from the use of such forms as thermal, mechanical, or chemical resources.

Process/Skill Questions

- What are examples of kinetic and potential energy?
- What is the difference between power and energy? What are examples of each?
- What are examples of energy doing work? How is the rate of power measured?

ITEEA National Standards

2. The Core Concepts of Technology

TSA Competitive Events

Technology Bowl

Task Number 40

Identify units of measurement related to power.

Definition

Identification should include

- amps
- watts
- volts
- ohms
- Roentgen equivalent man (REM)
- gallons per minute (GPM)
- rads
- British thermal units (BTUs)
- calories
- horsepower
- pounds per square inch (PSI)
- torque
- Fahrenheit
- pounds per hour.

Process/Skill Questions

- How do the different units of measurement depict different aspects of power?
- What types of energy are associated with each unit of measurement?

ITEEA National Standards

3. The Relationships Among Technologies and the Connections Between Technology and Other Fields

---

Task Number 41

Describe the primary forms of energy and their uses.

Definition

Description should include

- thermal – internal energy of a system in thermodynamic equilibrium by virtue of its temperature, used for such things as home heating, transportation, cooking, water heating, industrial production, boilers, nuclear medicine, and x-rays

- mechanical – energy associated with the motion and position of an object, used for such things as transportation, power production, wind turbines, and steam turbines
- chemical – energy derived from chemical reactions (e.g., batteries, fuel, food), used for such things as transportation and electronics
- electrical – energy made available by the flow of electric charge through a conductor for residential, commercial, and industrial use
- radiant – energy transferred by electromagnetic radiation (e.g., light)
- nuclear – energy stored in the nuclei of atoms
- sound – produced by vibrations, when energy travels through a substance in the form of waves
- elastic – potential energy stored in a coiled spring
- gravitational – potential energy stored in objects higher than the ground.

Process/Skill Questions

- Under which form of energy does solar photovoltaic (PV) energy fall?
- What is *hybrid energy*?
- On what form of energy does a battery operate? Why is that the best choice?
- What forms of energy are used in the transportation industry?

ITEEA National Standards

2. The Core Concepts of Technology

TSA Competitive Events

Essays on Technology

Technology Bowl

Task Number 42

Describe how renewable and non-renewable sources of energy are used.

Definition

Description should include the characteristics and uses of

- renewable sources
    - hydro (dams)

    - solar photovoltaics
    - wind
    - tidal/currents and waves
    - geothermal (natural steam vents)
    - biomass
- non-renewable sources
    - fossil fuels (e.g., coal, natural gas, liquid propane [LP] gas, oils)
    - nuclear (uranium)
    - recycled oils.

Process/Skill Questions

- What is the environmental impact of each of the sources of energy?
- Which sources of energy give off the most radiation?
- Which sources of energy would be considered baseloads, and why?
- How can we evaluate the cost effectiveness of a new energy source?

ITEEA National Standards

16. Energy and Power Technologies

5. The Effects of Technology on the Environment

TSA Competitive Events

Technology Bowl

Task Number 43

Demonstrate energy transformation.

Definition

Demonstration should include

- the relationship between the source and the final output
- energy transfer and storage
- energy efficiency – loss of energy in the transformation process (i.e., put in 100 percent, never get 100 percent out).

Teacher resource:
The National Energy Education Development (NEED) Project

Process/Skill Questions

- What is the definition of *efficiency*?
- What are some common byproducts of energy transformation?
- What can an individual do to contribute to energy efficiency?
- What are direct applications of converting an energy source to power?

ITEEA National Standards

12. Use and Maintain Technological Products and Systems

TSA Competitive Events

Biotechnology Design

Task Number 44

Define electrical energy.

Definition

Definition should include the concept that electrical energy is a secondary energy source, made primarily from mechanical (e.g., turbines) or chemical (e.g., batteries) energy. Electricity is the flow of electric charge through a conductor for residential, commercial, or industrial use.

Teacher resource:
Energy Information Administration

Process/Skill Questions

- Why is electrical energy a secondary energy source?
- What does electric charge mean?
- How does electricity work?

ITEEA National Standards

2. The Core Concepts of Technology

Exploring Electricity and Gas Fundamentals

Task Number 45

Follow safety guidelines.

Definition

Following safety guidelines should include

- Occupational Safety and Health Administration (OSHA) guidelines for construction and general industry
    - personal protective equipment (PPE)
    - lockout/tagout procedures
- manufacturer guidelines for maintenance and use of tools and equipment
- lab safety rules.

Process/Skill Questions

- What are examples of job site hazards?
- Why is it important to store materials and tools in their proper places?
- What is the purpose of safety data sheets (SDS)?
- What is the unseen hazard with electrical work?
- What is the definition of *proximity work*?
- What are minimum approach distances for qualified and nonqualified workers?
- Why is jewelry not allowed on the work site?
- Who is authorized to remove a lockout and tagout?

ITEEA National Standards

12. Use and Maintain Technological Products and Systems

Task Number 46

Demonstrate the use of tools and applications in electricity and gas.

Definition

Demonstration may include

- basic insulated hand tools used for electricity (e.g., screwdrivers, stripping tools, wire cutters, crimpers, wrenches)
- basic hand tools used for gas (e.g., wrenches, pipe cutters, pipe threaders, shovels)
- applications (e.g., gauging, measuring, connecting, terminating, grounding).

Process/Skill Questions

- Why does one use insulated hand tools for work with electricity?
- What is the procedure for threading pipe?
- Why should tools be inspected before use?
- What is the approximate cost of tools for the entry-level electrician?

ITEEA National Standards

12. Use and Maintain Technological Products and Systems

Task Number 47

Demonstrate the use of instruments to measure units.

Definition

Demonstration should include collecting data (e.g., wattage, voltage, amperage, torque, temperature, resistance, pressure) and may include the following instruments:

- Multimeter (e.g., digital, analog)
- Ammeter
- Voltmeter
- Torque wrench
- Pressure gauge
- Control valve
- Spring scale
- Thermometer (e.g., red alcohol, mercury, laser, probe)

Process/Skill Questions

- How does one read the amperage of a motor?
- What type of meter does one use to read voltage?
- How is a home blood pressure monitor kit similar to some of these tools?

- What is the purpose of the spring scale?
- What is the operation of a control valve?

ITEEA National Standards

12. Use and Maintain Technological Products and Systems

16. Energy and Power Technologies

3. The Relationships Among Technologies and the Connections Between Technology and Other Fields

TSA Competitive Events

Principles of Technology (Virginia only)

Task Number 48

Convert units of measure.

Definition

Conversion should include the use of unit conversion charts and formulas (e.g., Watt's law, Ohm's law, ideal gas law) to convert

- metric to standard units, and vice versa
- among different scientific notation (e.g., kilo-, mega-, giga-, micro-)
- from parts per million (PPM) to lower explosive limit (LEL) to percent gas, and vice versa
- BTUs to therms.

Process/Skill Questions

- How can one calculate resistance of a circuit, using Ohm's law?
- What are three different ways of using Ohm's law?
- What is the fractional equivalent of 6mm?
- What is the relationship between voltage, amperage, and wattage?
- What is the origin of BTU?

ITEEA National Standards

3. The Relationships Among Technologies and the Connections Between Technology and Other Fields

---

Task Number 49

Describe characteristics of series, parallel, and combination circuits.

Definition

Description should include

- components of a circuit (e.g., power supply, load, regulators, switches, transformers, fuses, wires)
- drawing basic schematics
- calculating voltage, amperage, and resistance
- applications of each type of circuit.

Process/Skill Questions

- What are the advantages and disadvantages of each type of circuit?
- How does a transformer work?
- What are some examples of loads?
- What is the purpose of a regulator?
- What are five schematic symbols?

ITEEA National Standards

12. Use and Maintain Technological Products and Systems

16. Energy and Power Technologies

TSA Competitive Events

Principles of Technology (Virginia only)

Understanding the Electrical Grid

Task Number 50

Define the grid.

Definition

Definition should include

- the grid – transmission network
- difference between transmission and distribution
    - transmission – the process of delivering energy (115 to 500 kV) from generation/production to substation
    - distribution – the process of delivering energy (120 V to 34.5 kV) from substation to the end user
- components of the transmission grid
    - power station
    - step-up transformers
    - switchyard
    - transmission towers
    - transmission lines (overhead and underground)
    - transmission substations
    - regulators
- components of the distribution grid
    - distribution substations
    - step-down transformers
    - breakers/fuses
    - switches
    - distribution lines (overhead and underground)
    - utility poles
    - regulators
    - inverters.

Process/Skill Questions

- What is the purpose of the step-up transformer? Step-down transformer?
- What are the main differences between transmission grids and distribution grids?
- What is the purpose of a breaker or fuse in the distribution grid?

ITEEA National Standards

12. Use and Maintain Technological Products and Systems

13. Assess the Impact of Products and Systems

16. Energy and Power Technologies

TSA Competitive Events

Technology Bowl

Task Number 51

Explain the history of the grid.

Definition

Explanation should include

- the contributions of Thomas Edison and Nikola Tesla
- alternating current (AC) vs. direct current (DC)
- long-distance vs. local transmission
- single-phase vs. three-phase power.

Process/Skill Questions

- What is a basic explanation for the Niagara power project?
- What are some of Edison's greatest contributions to the grid?
- What is the impact of Tesla's work on today's transmission and distribution grid?

ITEEA National Standards

16. Energy and Power Technologies

7. The Influence of Technology on History

Task Number 52

Illustrate the grid.

Definition

Illustration should include showing

- how the different components of the grid are connected from generation to end user
- the technical attributes of each component
- the mechanisms, tools, and equipment involved in each component of the grid
- the process of converting DC to AC and when it is used (i.e., from transmission to distribution).

Teacher resource:
KidWind

Process/Skill Questions

- How does protective equipment make the grid more efficient?
- How do the components of the grid work together?
- How could one make the grid more efficient?
- How could one modernize the grid?

ITEEA National Standards

12. Use and Maintain Technological Products and Systems

13. Assess the Impact of Products and Systems

16. Energy and Power Technologies

Task Number 53

Research career opportunities in electric transmission and distribution.

Definition

Research should include

- postsecondary training
    - registered apprenticeship programs
    - two- and four-year colleges
    - military training
    - adult learning centers
    - professional/private education agencies
    - cooperative education

    - work-based learning
    - workshops conducted by the Department of Professional and Occupational Regulations (DPOR)
- various occupations (e.g., ground worker, line worker, grid operator, substation engineer, distribution engineer, meter servicer, customer service representative, manager)
- certifications (e.g., Association of Energy Engineers [AEE])
- national/local trade organizations.

Process/Skill Questions

- How many jobs are available in the energy sector?
- What is the role of a journeyman electrician?
- What is the role of a lawyer in the energy industry?
- What are some trade organizations that support energy employees?
- What energy careers offer the highest salaries with the least amount of schooling?

ITEEA National Standards

12. Use and Maintain Technological Products and Systems

16. Energy and Power Technologies

Understanding Gas Systems

Task Number 54

Define a natural gas system.

Definition

Definition should include

- components of the gas system (e.g., compressors, regulators, valves, transmission/distribution lines, heaters, pipes, gathering lines, wells, meters/metering stations, service lines, underground storage, propane air plants, liquefied natural gas [LNG], processing plants, pumping stations)
- pressure distinction
- the difference in use of steel and plastic pipelines

- the distinction between transmission class (20 percent specified minimum yield strength [SMYS]) and distribution class (<20 percent SMYS)
- pressure and volume measurements
- corrosion and its effect on buried pipelines
- the use of mercaptan.

Process/Skill Questions

- What home appliances could use natural gas?
- Why is mercaptan added to natural gas?
- How are propane air and LNG used to supplement gas supply?
- Why is natural gas storage important, and when is it used?
- What is the difference between a leak and a rupture?
- What devices are used to internally inspect pipeline components?

ITEEA National Standards

12. Use and Maintain Technological Products and Systems

16. Energy and Power Technologies

Task Number 55

Identify uses of natural gas.

Definition

Identification should include

- residential
- commercial
- industrial
- electric generation.

Teacher resource:
Energy Information Administration

Process/Skill Questions

- What are some residential uses of natural gas?
- What are the benefits of using natural gas in a commercial setting?
- Why is electric generation the highest percentage of natural gas use?

ITEEA National Standards

12. Use and Maintain Technological Products and Systems

16. Energy and Power Technologies

Task Number 56

Explain key developments in gas systems.

Definition

Explanation should include

- the discovery of gas
- when gas was first extracted for production
- the significance of the New London, Texas explosion.

Process/Skill Questions

- When was the first discovery of natural gas in America? In the world?
- What is hydraulic fracturing?
- What caused the New London, Texas explosion?

ITEEA National Standards

16. Energy and Power Technologies

7. The Influence of Technology on History

Task Number 57

Illustrate a gas system.

Definition

Illustration should include

- how different parts of the gas system are connected
- the mechanisms, tools, and equipment involved in each part of the system

- how gas is transmitted from production to the end user.

Process/Skill Questions

- In what ways could a gas system fail?
- What components make up a gas system?
- How does gas transmission differ from electric transmission?

ITEEA National Standards

12. Use and Maintain Technological Products and Systems

13. Assess the Impact of Products and Systems

16. Energy and Power Technologies

Task Number 58

Research career opportunities in gas transmission and distribution.

Definition

Research should include

- postsecondary training
    - registered apprenticeship programs
    - two- and four-year colleges
    - military training
    - adult learning centers
    - professional/private education agencies
    - cooperative education
    - work-based learning
    - workshops conducted by the Department of Professional and Occupational Regulations (DPOR)
- various occupations (e.g., corrosion technician, plant technician, service technician, measurement and regulation technician, leakage inspector, damage prevention specialist, equipment operator, operations engineer, field engineer, contract inspectors, pipe fitter, drilling engineer, safety specialist, geologist, roustabout)
- certifications (e.g., National Association of Corrosion Engineers [NACE], Association of Energy Engineers [AEE])
- national/local trade organizations.

Process/Skill Questions

- Which jobs in natural gas require a certification or degree?
- What training opportunities are available locally?
- What are some major distribution and transmission providers in the state?

ITEEA National Standards

16. Energy and Power Technologies

6. The Role of Society in the Development and Use of Technology

---

Investigating Regulatory Policies in Energy

Task Number 59

Describe how federal and state agencies regulate the energy business.

Definition

Description should include how the following agencies regulate transmission and distribution:

- Virginia's State Corporation Commission (SCC)
- Pipeline and Hazardous Materials Safety Administration (PHMSA)
- Federal Energy Regulatory Commission (FERC)

Process/Skill Questions

- What are the regulations regarding who can be an energy supplier?
- When is curtailment necessary?
- Who decides when and how to curtail energy?
- What factors constrain markets?

ITEEA National Standards

16. Energy and Power Technologies

4. The Cultural, Social, Economic, and Political Effects of Technology

6. The Role of Society in the Development and Use of Technology

---

Task Number 60

Identify other agencies involved in the permitting and oversight of energy businesses.

Definition

Identification should include

- state agencies
  - Virginia Department of Environmental Quality (DEQ)
  - Virginia Department of Transportation (VDOT)
  - Virginia Department of Mines, Minerals, and Energy (DMME)
  - Virginia's State Corporation Commission (SCC)
  - Virginia Department of Labor and Industry (DOLI) and Virginia Occupational Safety and Health (VOSH) Safety Compliance Division
  - Virginia Department of Health (VDH)
- federal agencies
  - Rural Utilities Service (RUS)
  - Federal Communications Commission (FCC)
  - Federal Aviation Administration (FAA)
  - U.S. Department of Defense (DOD)
  - U.S. Environmental Protection Agency (EPA)
  - U.S. Nuclear Regulatory Commission (NRC)
  - Occupational Safety and Health Administration (OSHA).

Process/Skill Questions

- How do agency leadership and funding affect regulation enforcement?
- Why is energy regulated?
- What is the difference between permitting and oversight?

ITEEA National Standards

16. Energy and Power Technologies

4. The Cultural, Social, Economic, and Political Effects of Technology

6. The Role of Society in the Development and Use of Technology

---

Task Number 61

Describe the role of independent regional transmission organizations (RTOs).

Definition

Description should include

- how RTOs were created
- the purpose of RTOs
- examples of RTOs (e.g., PJM, GO 15, ISO New England, Electric Reliability Council Texas [ERCT]).

Process/Skill Questions

- What are the RTOs in the United States?
- What are the benefits of RTO membership?
- Why do some states choose not to participate in an RTO?

ITEEA National Standards

4. The Cultural, Social, Economic, and Political Effects of Technology

6. The Role of Society in the Development and Use of Technology

---

Task Number 62

Research regulations that ensure public safety.

Definition

Research may include

- Underground Utility Damage Prevention Act
- Virginia Overhead High Voltage Line Safety Act

- the role of utility companies in driving and upholding public safety legislation.

Teacher resource:
American Petroleum Institute RP 1173

Process/Skill Questions

- When were key safety laws enacted? Why were they enacted?
- How have these laws promoted public safety?
- What role does the individual play in public safety?

ITEEA National Standards

16. Energy and Power Technologies

4. The Cultural, Social, Economic, and Political Effects of Technology

6. The Role of Society in the Development and Use of Technology

---

Exploring Technology Trends in Energy

Task Number 63

Define distributed energy.

Definition

Definition should include energy sources that supply power onsite or locally, such as

- rooftop solar panels or solar gardens
- biogas digesters
- wind turbines powering a facility
- solar-thermal technology
- backup generators
- combined heat and power plants.

Process/Skill Questions

- What is *cogeneration*?
- What are aggregated distributed energy resources?
- Why is it important to have a backup energy resource?

ITEEA National Standards

12. Use and Maintain Technological Products and Systems

TSA Competitive Events

Essays on Technology

Task Number 64

Describe microgrids.

Definition

Description should include

- the definition of microgrid
- benefits of microgrids (e.g., resiliency, load balancing)
- uses of microgrids (e.g., university campus, military base, island community).

Process/Skill Questions

- What are examples of microgrids in Virginia?
- What are the benefits and challenges of using microgrids?

ITEEA National Standards

12. Use and Maintain Technological Products and Systems

Task Number 65

Design a microgrid.

Definition

Design may include the use of paper, computer technology, or models.

Process/Skill Questions

- What are some of the sources of microgrid energy?
- How is energy controlled in a microgrid?
- How is energy stored and distributed in a microgrid?

ITEEA National Standards

10. The Role of Troubleshooting, Research and Development, Invention and Innovation, and Experimentation in Problem Solving

9. Engineering Design

Task Number 66

Compare a smart grid to a traditional distribution grid.

Definition

Comparison should include

- definition of *smart grid*
- components of a smart grid (e.g., automated meter infrastructure [AMI], controllers, smart protective devices, grid automation)
- benefits of smart grids (e.g., two-way measurement of electricity, resiliency, load balancing, efficiency, data collection)
- reasons that transmission and distribution operators are moving toward the use of smart grids (e.g., new capacities, new constraints, changing supply).

Process/Skill Questions

- Why are smart grids used for distributed generation?
- What are the key components of a smart grid?
- What is the difference between a smart grid and a microgrid?

ITEEA National Standards

11. Apply the Design Process

Task Number 67

Research trends in energy storage.

Definition

Research may include

- pumped storage
- other gravitational storage
- air storage
- battery storage.

Process/Skill Questions

- How is energy stored and distributed in a microgrid?
- What are the different pumped storage technologies being researched?
- What are the different battery types being used?

ITEEA National Standards

10. The Role of Troubleshooting, Research and Development, Invention and Innovation, and Experimentation in Problem Solving

16. Energy and Power Technologies

Task Number 68

Investigate research and development (R&D) that address future challenges in energy.

Definition

Investigation may include

- grid modernization and resiliency
- development of an offshore grid (e.g., offshore wind)
- cybersecurity
- energy demand vs. supply
- sustainability.

Process/Skill Questions

- How has the supply of energy changed since solar energy became widely available?
- How has artificial intelligence (AI) affected energy supply?
- How has grid modernization increased the reliability of the grid?

ITEEA National Standards

10. The Role of Troubleshooting, Research and Development, Invention and Innovation, and Experimentation in Problem Solving

12. Use and Maintain Technological Products and Systems

13. Assess the Impact of Products and Systems

SOL Correlation by Task

39	Define *energy*.	English: 9.3, 10.3 Science: PH.5, PH.6
40	Identify units of measurement related to power.	English: 9.5, 10.5 Science: PH.11
41	Describe the primary forms of energy and their uses.	English: 9.5, 10.5 Science: PH.7
42	Describe how renewable and non-renewable sources of energy are used.	English: 9.5, 10.5 Science: ES.6
43	Demonstrate energy transformation.	
44	Define electrical energy.	English: 9.3, 9.8, 10.3, 10.8 Science: PH.11
45	Follow safety guidelines.	English: 9.5, 10.5 History and Social Science: GOVT.7, GOVT.8
46	Demonstrate the use of tools and applications in electricity and gas.	
47	Demonstrate the use of instruments to measure units.	Science: PH.11
48	Convert units of measure.	Mathematics: A.1, A.4, AII.3

		Science: PH.11
49	Describe characteristics of series, parallel, and combination circuits.	English: 9.5, 10.5 Mathematics: A.1, A.4, AII.3 Science: PH.11
50	Define the grid.	English: 9.3, 9.5, 10.3, 10.5
51	Explain the history of the grid.	English: 9.5, 10.5
52	Illustrate the grid.	
53	Research career opportunities in electric transmission and distribution.	English: 9.5, 9.8, 10.5, 10.8
54	Define a natural gas system.	English: 9.3, 9.5, 10.3, 10.5
55	Identify uses of natural gas.	English: 9.5, 10.5
56	Explain key developments in gas systems.	English: 9.5, 10.5
57	Illustrate a gas system.	
58	Research career opportunities in gas transmission and distribution.	English: 9.5, 9.8, 10.5, 10.8 History and Social Science: GOVT.7, GOVT.8
59	Describe how federal and state agencies regulate the energy business.	English: 9.5, 10.5 History and Social Science: GOVT.7, GOVT.8, GOVT.9, GOVT.14, GOVT.15
60	Identify other agencies involved in the permitting and oversight of energy businesses.	English: 9.5, 9.8, 10.5, 10.8 History and Social Science: GOVT.7, GOVT.8, GOVT.9, GOVT.14, GOVT.15
61	Describe the role of independent regional transmission organizations (RTOs).	English: 9.5, 10.5
62	Research regulations that ensure public safety.	English: 9.5, 9.8, 10.5, 10.8
63	Define distributed energy.	English: 9.3, 9.5, 10.3, 10.5
64	Describe microgrids.	English: 9.5, 10.5
65	Design a microgrid.	English: 9.1, 9.2, 10.1, 10.2
66	Compare a smart grid to a traditional distribution grid.	
67	Research trends in energy storage.	English: 9.5, 9.8, 10.5, 10.8
68	Investigate research and development (R&D) that address future challenges in energy.	English: 9.5, 9.8, 10.5, 10.8

Appendix: Credentials, Course Sequences, and Career Cluster Information

Industry Credentials: Only apply to 36-week courses

- Building Science Principles Examination
- College and Work Readiness Assessment (CWRA+)
- Energy Industry Fundamentals Certificate Assessment
- National Career Readiness Certificate Assessment
- Workplace Readiness Skills for the Commonwealth Examination

Concentration sequences: *A combination of this course and those below, equivalent to two 36-week courses, is a concentration sequence. Students wishing to complete a specialization may take additional courses based on their career pathways. A program completer is a student who has met the requirements for a CTE concentration sequence and all other requirements for high school graduation or an approved alternative education program.*

- Energy Transmission and Distribution, Advanced (TD8411/36 weeks)

Career Cluster: Energy	
Pathway	**Occupations**
Energy Efficiency	**Electrical Engineer** **Electrician** **Environmental Engineer** **Environmental Engineering Technician** **Environmental Science and Protection Technician** **Environmental Scientist** **HVAC and Refrigeration Mechanic or Installer**
Fuels Production	**Chemical Engineer** **Chemist** **Continuous Mining Machine Operator** **First-Line Supervisor of Transportation and Material-Moving Machine and Vehicle Operator** **Geological Technician** **Petroleum Engineer** **Petroleum Technician** **Service Unit Operator, Oil, Gas, and Mining**

Career Cluster: Energy	
Pathway	**Occupations**
	Wellhead Pumper
Power Generation	**Control and Valve Installer, Repairer** **Electrical Engineering Technician** **Electronics Engineer** **Electronics Engineering Technician** **Engineering Manager** **Health and Safety Engineer** **Mechanical Engineer** **Nuclear Engineer** **Nuclear Power Reactor Operator** **Nuclear Technician** **Solar Photovoltaic Installer**
Transmission and Distribution	**Electrical and Electronics Repairer, Powerhouse, Substation and Relay** **Electrical Power Line Installer/Repairer** **Electro-Mechanical Technician** **Gas Compressor and Gas Pumping Station Operator** **Pipefitter, Steamfitter** **Plumber** **Power Distributor, Dispatcher** **Wind Turbine Service Technician**

Career Cluster: Science, Technology, Engineering and Mathematics	
Pathway	**Occupations**
Engineering and Technology	**Chemical Engineer** **Civil Engineer** **Civil Engineering Technician** **Computer Hardware Engineer** **Computer Programmer** **Computer Software Engineer** **Electrical Drafter** **Electrical Engineer** **Electrical Engineering Technician** **Electro-Mechanical Technician** **Electronic Drafter** **Electronics Engineering Technician** **Engineer** **Engineering Manager** **Engineering Technician** **Environmental Engineer** **Mechanical Drafter** **Mechanical Engineer** **Mechanical Engineering Technician** **Network Systems and Data Communication Analyst** **Nuclear Engineer** **Petroleum Engineer** **Pipeline Drafter** **Power Systems Engineer** **Quality Engineer**

Career Cluster: Science, Technology, Engineering and Mathematics	
Pathway	**Occupations**
	Quality Technician **Statistician** **Systems Analyst** **Transportation Manager**
Science and Mathematics	**Chemist** **Ecologist** **Environmental Scientist** **Geodetic Surveyor** **Geoscientist** **Research Chemist**

Career Cluster: Transportation, Distribution and Logistics	
Pathway	**Occupations**
Health, Safety and Environmental Management	**Health, Safety, and Environment Manager**
Logistics Planning and Management Services	**Logistics Engineer**